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LXXIX. *Farther Experiments in Electricity;*
by Mr. Benjamin Wilson, F. R. S.

*To the Right Honourable the Earl of Macclesfield,
President of the Royal Society.*

My Lord,

Read Nov. 13, 1760. **I**N my letter upon the *Tourmalin*, which I had the honour of communicating to the Royal Society in December last, there are some experiments to shew, that glass is permeable by electricity. I have since made others of the like kind, which seem to favour the same opinion.

The high regard your Lordship has always shewn for experimental philosophy, encourages me to lay before you these experiments, with a few others, of a very curious nature.

But I beg leave, first, to take notice, that our electrical apparatus is much improved, by the discovery of Father *Windelinus Ammerfin*, of *Switzerland*, who, in a Latin treatise published in 1754, has shewn us, that *wood*, properly dried, till it becomes very brown, is a non-conductor of electricity*; and recommends boiling the wood in linseed oil, or covering it all over with varnish, after being dried, to prevent any return of moisture into its pores. He

* It appears, from the Philosophical Transactions, so early as the year 1747, that Dr. *Watson* having occasion to support a long wire, in the experiment made near Shooter's Hill, with a view to determine the velocity of the electric fluid, used stakes of dry wood, (which, he tells me, were baked) to prevent the electric fluid from escaping into the ground.

adds,

adds, that wood so treated seems to afford stronger appearances than even glass *.

The following experiments were made, with the assistance of wood thus prepared.

Being provided with a large square of glass, polished on both sides, and fixed upright upon one edge, I placed, for a conductor, a slender piece of ivory, about one foot long, having one end within two tenths of an inch from the center of the glass: at the other end were suspended two small balls of pith, by threads four inches long. The ivory was supported horizontally by a stand made of the *prepared wood*. When the glass was made a little warmer than the external air, my finger rubbed that side thereof which was farthest from, and opposite to, the ivory. Upon doing this, the two sides of the glass were electrified *plus*, as were likewise the balls; which continued *plus*, even after they were removed from the glass into any part of the room.

From the appearance of a *plus* electricity in the ivory, as well as on the two sides of the glass, the fluid must have flowed from the finger into the glass, and part of it into the ivory: otherwise, permit me to ask how the ivory should be electrified *plus*?

That the fluid really flowed from the finger into the glass, may be inferred from the following experiment.

A piece of silver, being fixed upon a slender rod of prepared wood, I rubbed the same glass with it, as I had done before with the finger; upon which the

* See the Abbé Nollet's Letters upon Electricity, published at Paris in 1760.

silver was electrified *minus*, and both sides of the glass, with the conductor and balls, *plus*.

There are, therefore, certain circumstances under which the electric fluid passes through glass; I repeat in *certain circumstances*, my Lord, because in others, for instance, the *Leyden bottle*, the fluid does not pass through the glass, but electrifies one side *plus*, and the other side *minus*, as my friend Dr. *Franklin* hath shewn, in his letters upon electricity.

This difference, which is caused by the vitreous electricity in both cases, may perhaps be explained from the *surrounding medium**, and the different degrees of the *power* with which the electric fluid endeavours to enter a body.

For the *resistance* owing to the *surrounding medium* in a polished plane, without covering, is not overcome, but by bringing the *power* near the glass, whereby the glass is electrified *plus* on both sides; whereas, when the glass is *properly covered*, and the *power* brought upon it, the covering conducts the fluid equally to all the parts on that side, where it accumulates, that is, electrifies it *plus*; whilst the opposite covering carries off to the communicating earth an equal quantity of the fluid naturally belonging to the glass, that is, electrifies it *minus*.

The same glass, without any covering, will be rendered *minus* on both sides, by removing the *power* to a greater distance, by which it is diminished, and the quantity of intermediate air, and consequently of *resistance*, increased.

* See the former paper upon the Tourmalin, p. 329. of this Volume, Part I.

The *power* therefore which causes the *minus* effect, is less than the *power* which causes the *plus* effect: and that this *minus* effect arises intirely from the *repulsive power* of the fluid, appears from this, that part of the fluid naturally belonging to the glass, is driven off, and electrifies *plus* other bodies placed beyond it.

From hence I collect, that the *three different effects*, viz. the electrifying glass *plus on both sides*; or *plus on one side*, and *minus on the other*; or, lastly, *minus on both sides*; are occasioned by the *different degrees* of the *same power* and *resistance* in the respective experiments with the *same glass*.

If, on the other hand, the three last experiments are made with the *minus*, instead of the *plus* electricity, the appearances, and consequently the reasoning upon them, are inverted: for the *plus* appearance, in that case, must be owing to the tendency of the fluid from the earth, air, and other neighbouring bodies, towards the opposite side of the glass, where the *power* acts, which causes the *minus* appearance.

This regular conversion serves to confirm the truth of the principles assigned.

And here, with your Lordship's leave, I shall set down some farther experiments, most of which have been made with a view to shew, that a *plus* electricity may be produced by means of a *minus* electricity.

Having electrified the inside of a large *Leyden* bottle *plus*, by means of a conducting-wire from an excited glass globe, I set it upon a stand of prepared wood, and took away the conducting-wire; after which, the mouth of the bottle was closed with a

stopple of glass. Then the pointed end of the ivory conductor was brought opposite to the middle of the bottle, and about two inches from it. Upon doing this, the balls were electrified *minus*; and more so, as the ivory was moved nearer the bottle in an horizontal direction.

But, on removing the ivory to a greater distance, the *minus* electricity decreased; and, at a certain distance, there was not any sign thereof remaining: and when the distance was increased to about eighteen inches from the bottle, a *plus* electricity appeared, which continued, even after the ivory was removed intirely away.

After unelectrifying the bottle, it was set again upon the stand of wood; and upon another of the same kind, was laid a large iron poker, so that the pointed end was about two inches from the outside coating, and much nearer the bottom than the top of the bottle. I chose the lower part thereof, for no other reason, than to have the poker out of the reach of any effect that might happen from the conducting-wire, which communicated with the machine, and the inside coating of the bottle. The other end of the poker, being a large round knob, was about one inch from a rod of iron, which communicated with the earth. Under these circumstances, when the inside of the bottle was electrified *plus*, the outer coating became *minus*, as usual.

It is to be observed here, that the *plus* appearance in the poker was caused by that portion of the fluid, which was driven off from the outside of the bottle, by the repulsive force of the fluid conveyed into the bottle. And this confirms the reasoning upon the remarkable

markable experiments related in the treatise published by Dr. Hoadly and myself. See p. 27 to 34, and 46, 47.

Instead of electrifying the inside of the bottle, in the last experiment, *plus*, I electrified it *minus*, with the prepared wood, without any other change of circumstances. In this case, the outside of the bottle was *plus*, as usual, and the poker *minus*. The fluid, therefore, which caused the *plus* electricity on the outside of the bottle, must, in part at least, have flowed from the poker; because there was no other open communication with the outside of the bottle and the earth to supply it.

With a cylinder of baked wood, which shewed stronger signs of electricity, than I have yet been able to produce from glass, the balls hanging to the ivory were electrified *minus*, at the distance of four feet, or more, by holding the cylinder over the middle of the ivory, and continuing it there: and on moving it nearer, they were more strongly electrified *minus*; but the same cylinder, on removing it back again to the distance of two or three feet, or more, electrified the balls *plus*.

When another conductor, for instance metal, without edges or points, was used instead of the ivory, and without any thing hanging from it, the same cylinder held over the metal, as was done in the last experiment over the ivory, at the distance of two feet, produced a *plus* electricity: and this was rendered weaker, as the cylinder was moved nearer; but by lessening the distance to about one foot, the *minus* electricity took place.

In these cases, the *plus* appearance arose from the earth, air, or other neighbouring bodies.

When the preceding experiments were first made, I was a little embarrassed with the uncertain appearances of a *plus* electricity at one time, and a *minus* at another, in the same experiment: but, by repeated trials and observations, I have found that a *plus* or *minus* electricity may be produced at pleasure, by carefully attending to the following circumstances, *viz.* the form of the bodies, their sudden or gradual removal, and the degrees of electrifying.

I shall now proceed to acquaint your Lordship with some other circumstances of as nice a nature, where the slightest, and almost imperceptible differences in the *position*, or in the *force* of the *friction*, of two bodies, produce in either of them, the *plus* electricity at one time, and the *minus* at another.

Such are the effects of this subtle and active fluid, when the experiments are carefully made; and therefore, they require the most scrupulous attention, to trace out the causes which occasion them.

Sealing wax and silver were the bodies used in the first two experiments; but many other substances seem to perform as well. The sealing wax was clean, and undisturbed by any friction whatever, but that of the air surrounding it; and had been so for some hours. The silver was fixed to a piece of the prepared wood, which was also preserved from friction for the same length of time. Then taking one of these substances in each hand, the silver being at that end of the wood the farthest from the hand, I laid the smoothest part of the silver upon the sealing wax, and moved it along the surface gently, *once only*, and with a very *slight pressure*; after which, the silver was electrified *plus*, and the wax *minus*.

On repeating the experiment, with equal care, and in the same manner, except that the *smooth side* of the silver was a little inclined, so that the *edge* thereof pressed against the wax; the silver, after moving it as before, was electrified *minus*, and the wax *plus*; which is contrary to what was observed in the last experiment.

These opposite effects, occasioned by the different applications of the flat, or edge of the silver, seem to arise from an alteration made in the surface of the wax, by *destroying* the *polish* in one case, and not in the other: and, in this respect, resembles the polished and rough glass mentioned in the letter upon the Tourmalin. See p. 328. of this Volume, Part I. Experiment 24.

Upon making use of prepared wood, instead of wax, and employing different degrees of pressure in the friction, with the *same edge* of the silver, I produced the like appearances; the least pressure causing a *plus*, and the greatest pressure a *minus* appearance in the silver.

A flat piece of steel, well polished, and the edges rounded off, afforded the same appearances, by only applying the *flat surface* to the wood; but it required more *pressing* to produce the *minus* effect in this case, than it did in the former, where the *edge* was concerned.

Whether the reason offered above for explaining these last curious appearances be true or not, I do not venture to affirm, for want of farther experiments; but thus much may be safely advanced, that we have learned to produce at pleasure the *plus* or *minus* electricity from the same bodies, by attending to the manner of their *application* and *friction*.

Mr. Dufay, and the Abbé Nollet, have indeed observed an inconstancy in the effects, when they rubbed sealing wax; but for want of the cautions above-described, in the choice and treatment of the bodies, they were not able to answer for the event of any experiment. The Abbé, in particular, who has taken remarkable pains to find out from whence this uncertainty arises, acquaints us, in the *thirteenth letter*, with his difficulties, and how much it perplexed him to see, within an hour, in the same place, and with the same instruments, the effects changed, and become altogether contrary to those he had before observed. In another part of the same letter, he says:

“ Je me suis flatté plus d’une fois d’avoir saisi les
 “ circonstances qui faisoient tourner à coup sûr le ré-
 “ sultat de l’expérience d’un côté ou de l’autre; mais
 “ la suite m’a fait connoître que je m’étois trompé,
 “ ou qu’il manquoit encore quelque chose à ma dé-
 “ coverte.”

I might add other quotations of the same kind, but, as it would take up too much of your Lordship’s time, I shall beg leave to refer to the letter itself.

From the experience now obtained, it may not be improper to observe farther, that sealing wax of different hardness, will occasion a difference in the effects, the hardest being always *plus*, and the softest *minus*; which agrees very well with the rule laid down in the letter upon the Tourmalin, p. 331, “ that where electric appearances are produced by
 “ the rubbing of any two polished bodies together,
 “ that body, whose substance is hardest, and electric
 “ power strongest, will be always *plus*, and the softest
 “ and weakest always *minus*.” Now we find that
 the

the Dutch wax is softer than the English, and the Irish harder : and it is not improbable that the French wax, which I suppose the *Abbé Nollet* used, may likewise be different.

Whoever, therefore, may be desirous of trying the preceding experiments, with a view to make them succeed, as they are here set down, must use the *best English sealing wax*.

I shall conclude with an experiment made by my friend *Mr. Hamilton*, professor of philosophy in the university of Dublin, as it seems to illustrate the doctrine of *resistances*, at least, so far as respects the air.

Let a slender brass, or iron wire, five or six inches long, and finely pointed at each end, be fitted in the middle, with a brass cap, void of angles ; then let half an inch at each extremity be bent in opposite directions, till they are perpendicular to the rest of the wire, and in such a manner, that when the wire is suspended, by means of its cap, on a point of metal, it may lie in a plane parallel to the horizon. The pointed metal, which supports this wire, must be two or three inches long, and have its other end fixed into a small block of wood. Now, if this block, with a wire suspended, be set upon an electrified body, the wire will turn round with a very great velocity, moving always in a direction contrary to that in which the electric fluid issues from its points, without having any conducting substance near it, save that of the air : and if the wire be made to turn round by any other force, in the opposite direction, so that its points go foremost, it will, when electrified, soon
be

be deprived of that motion, and made to turn round the contrary way.

This experiment, he says, was contrived, in order to try whether the electric fluid, which issues so freely from pointed bodies, would have any effect to move these bodies by its reaction; and that it has such an effect, seems sufficiently manifest from the event.

Mr. Hamilton apprehends, that the electric particles, by their elastic force, issue directly forwards from the points, and endeavour to expand themselves; but meeting with some resistance from the air, force the wire to move backward in a contrary direction, much in the same manner that a Catherine-wheel is made to turn round in a direction, contrary to that in which the small rockets affixed to its periphery discharge themselves. And therefore, he is inclined to think, that it might be made use of as an electrometer, by having it to turn round in a plane perpendicular to the horizon, and loading the wire with small weights near one of its extremities, which will be raised to a greater distance from the perpendicular line, as the electric fluid is stronger.

I am, my Lord,

Your Lordship's

most obliged

Great Queen-Street,
Nov. 5, 1760.

and obedient servant,

Benj. Wilson.